Claims

What is claimed is as follows:

(1) A composite structure comprised of a metal matrix having diamond particles dispersed therein, wherein said diamond particles are characterized by the presence of a layer of beta-SiC chemically bonded to the surface thereof.

(2) The structure of claim 1, wherein the metal matrix is comprised essentially of a metal selected from aluminum, copper, magnesium, and alloys of one or more of said metals.

(3) The structure of claim 1 wherein the metal matrix material is essentially aluminum.

(4) The structure of claim 1wherein the metal matrix material is essentially copper.

(5) A method of forming a composite structure comprised essentially of a metal matrix having diamond particles dispersed therein, and wherein said diamond particles are characterized by the presence thereon of a surface layer of beta-SiC chemically bonded thereto, comprising the steps of contacting the surface of said diamond particles with a source of Si under conditions whereby the Si is chemically reacted with C comprising the surface of the diamond particles, thereby forming said surface layer of beta-SiC bonded to said diamond particles, wherein said composite structure is formed by assembling a plurality of said diamond particles in an array, and encapsulating the particles of said array with said metal in a molten state whereby the particles of said array bearing the surface layer of beta-SiC are dispersed in a matrix of said metal when the molten metal hardens upon cooling to the solid state.

(6) The method of claim 5 wherein the surface layer of beta-SiC is formed on said diamond particles by contacting said diamond particles with the source of Si prior to assembling said particles in said array.

(7) The method of claim 5 wherein the surface layer of beta-SiC is formed on said diamond particles by contacting said diamond particles with the source of Si subsequent to assembling said particles in said array.

(8) The method of claim 5 wherein the array of diamond particles is encapsulated by the molten metal in the performance of a squeeze casting process to form said composite structure.

(9) The method of claim 6 wherein the array of diamond particles is encapsulated by the molten metal in the performance of a squeeze casting process to form said composite structure.

(10) The method of claim 7 wherein the array of diamond particles is encapsulated by the molten metal in the performance of a squeeze casting process to form said composite structure.

(11) The method of claim 6, wherein the Si that contacts the diamond particles is provided by SiO gas that is caused to contact the diamond particles.

(12) The method of claim 7, wherein the Si that contacts the diamond particles is provided by SiO gas that is introduced into the array of diamond particles.

(13) The method of claim 6 wherein the Si that contacts the diamond particles includes Si powder.

(14) The method of claim 7 wherein the Si that contacts the diamond particles includes Si powder.

(15) The method of claim 6 wherein the Si powder is mixed with phenolic resin.

(16) The method of claim 7 wherein the Si powder is mixed with phenolic resin.

(17) The structure of claim 1 wherein the carbon of the SiC is derived from the respective diamond particles to which it is bonded.

(18) The structure of claim 1 wherein the diamond particles are in the size range of 100 - 120 microns.

(19) An array of diamond particles characterized by the presence of a layer of beta SiC chemically bonded to the surface of the respective particles and whereon the carbon of the SiC is derived from the diamond of the respective diamond particles to which it is bonded.

20) A composite consisting of a powder comprising diamond particles, wherein the surface of the respective particles is converted to a thin SiC surface conversion coating, such coating being formed by a chemical vapor reaction of a gaseous Si source, with the respective diamond particle, and said SiC coated diamond powder being suitably bound in a metal matrix producing a composite with a thermal conductivity higher than the matrix.

21) A process to coat diamond powder with a thin SiC surface coating, wherein the diamond particles comprising the diamond powder are contacted by a gaseous Si containing species under conditions causing chemical vapor reaction between the gaseous Si containing species and the solid particles comprising the diamond powder, said SiC coated diamond powder being suitable to be encapsulated in a metal matrix to form a very high thermal conductivity metal matrix composite.

22) The process described in claim 21, wherein the gaseous species of Si is generated by the reduction of SiO_2 to form gaseous SiO.

23) A process to coat the particles comprising a diamond powder with a thin, in-situ SiC coating obtained by depositing a Si containing preceramic polymer layer on the diamond particle that can be converted to SiC by heating to a suitably high temperature to initiate the conversion of the diamond surface to SiC, but at a time insufficient to convert the diamond structure to graphite, said SiC coated diamond powder being suitable to form very high thermal conductivity metal matrix composites.

24) The process described in claim 23, wherein the conversion is carried out at a temperature of at least about 1500 degrees centigrade.

25) The process described in claim23, wherein the conversion is carried out at a temperature of at least about 1600 degrees centigrade.

26) The process described in claim 23, wherein the conversion is carried out at a temperature of at least about 1800 degrees centigrade.

27) The process described in claim 23, wherein the reaction time at maximum temperature is less than about 1 hour.

28) The process described in claim 23, wherein the reaction time at maximum temperature is less than about 1/2 hour.

29) The process described in claim 23, wherein the reaction time at maximum temperature is less than about 1/8 hour.

30) The process described in claim 23, wherein the reaction time at maximum temperature is less than about 1/10 hour.

31) A process to coat the particles comprising a diamond powder with a thin SiC surface conversion coating, wherein the coating is obtained by passing a reactive gaseous mixture over the diamond particles, such that the reactive gas produces a silicon containing species at a temperature that causes reaction between the silicon containing species and the diamond, but at a time and temperature insufficient to convert the diamond structure to graphite, said SiC powder being suitable to form very high thermal matrix composites.

32) The process described in claim 31, wherein the reaction is carried out at a temperature of at least about 1100 degrees centigrade.

33) The process described in claim 31, wherein the reaction is carried out at a temperature of at least about 1500 degrees centigrade.

34) The process described in claim 31, wherein the reaction is carried out at a temperature of at least about 1800 degrees centigrade.

35) The process described in claim 31, wherein the reaction time at maximum temperature is less than about 1 hour.

36) The process described in claim 31, wherein the reaction time at maximum temperature is less than about 1/2 hour.

37) The process described in claim 31, wherein the reaction time at maximum temperature is less than about 1/8 hour.

38) The process described in claim 31, wherein the reaction time at maximum temperature is less than about 1/10 hour.

39) A composite consisting of diamond particles, wherein the surface of the particles is converted to a thin SiC surface conversion coating, such coating being formed by

heating a preform of Si powder and diamond powder plus a binder, such as, but not limited to, phenolic resin, the purpose of said binder being to hold the Si in contact with the diamond surface, heating said preform to a temperature sufficient to cause the surface conversion reaction to occur, and said SiC conversion coated diamond powder being suitably bound in a metal matrix producing a composite with a thermal conductivity higher than the matrix.

40) A process to coat the particles compressing a diamond powder with a thin SiC surface coating, wherein a preform of phenolic resin, Si powder, and diamond powder are heated to a temperature sufficient to cause the surface conversion reaction to occur, said SiC coated diamond powder being suitable to form very high thermal conductivity metal matrix composites.

41) The composite described in claim 39, wherein the temperature to which the preform is heated is at least 1300 degrees centigrade.

42) The composite described in claim 39, wherein the temperature to which the preform is heated is at least 1400 degrees centigrade.

43) The composite described in claim 39, wherein the temperature to which the preform is heated is at least 1500 degrees centigrade.

44) The composite described in claim 39, wherein the temperature to which the preform is heated is at least 1600 degrees centigrade.

45) The composite described in claim 39, wherein the temperature to which the preform is heated is at least 1700 degrees centigrade.

46) The process described in claim 40, wherein the temperature to which the preform is heated is at least 1300 degrees centigrade.

47) The process described in claim 40, wherein the temperature to which the preform is heated is at least 1400 degrees centigrade.

48) The process described in claim 40, wherein the temperature to which the preform is heated is at least 1500 degrees centigrade.

49) The process described in claim 40, wherein the temperature to which the preform is heated is at least 1600 degrees centigrade.

50) The process described in claim 41, wherein the temperature to which the preform is heated is at least 1700 degrees centigrade.

51) A metal matrix composite comprising a matrix containing diamond powder, said diamond powder having a thin SiC surface layer on the respective diamond particles comprising said powder, said SiC layers being comprised of a conversion coating formed by a chemical vapor reaction of SiO with the respective diamond particles, and said metal matrix composite having a thermal conductivity greater than about 300W/m.k.

52) The composite described in claim 51, having a thermal conductivity greater than about 400W/m.k.

53) The composite described in claim 51, having a thermal conductivity greater than about 500W/m.k.

54) The composite described in claim 51, having a thermal conductivity greater than about 600W/m.k.

55) The composite of claim 51, wherein the metal employed is aluminum.

56) The composite of claim 52, wherein the metal employed is aluminum.

57) The composite of claim 53, wherein the metal employed is aluminum.

58) The composite of claim 54, wherein the metal employed is aluminum.

59) The composite of claim 51, wherein the metal employed is magnesium.

60) The composite of claim 52, wherein the metal employed is magnesium.

61) The composite of claim 53, wherein the metal employed is magnesium.

62) The composite of claim 54, wherein the metal employed is magnesium.

63) The composite of claim 51, wherein the metal employed is copper.

64) The composite of claim 52, wherein the metal employed is copper.

65) The composite of claim 53, wherein the metal employed is copper.

66) The composite of claim 54, wherein the metal employed is copper.

67) The composite described in claim 51, wherein the content of the CVR SiC coated diamond powder in the composite is about 10-60 vol% of the total.

68) The composite described in claim 51, wherein the content of the CVR SiC coated diamond powder in the composite is greater than about 70 vol% of the total.

69) The composite described in claim 51, wherein the content of the CVR SiC coated diamond powder in the composite is greater than 80 vol% of the total.

(70) The composite described in claim 51, wherein the particle size of the diamond powder used is preferably about 50-150 microns, and more preferably 100-120 microns.

(71) The composite described in claim 51, wherein the particle size of the diamond powder used is preferably greater than 150 microns.

(72) The composite described in claim 51, wherein the particle size of the diamond powder is greater than about 200 microns.

(73) The composite described in claim 51, wherein the particle size of the diamond powder is greater than about 300 microns.

(74) A metal matrix composite containing diamond powder, said diamond powder comprising diamond particles having a thin SiC surface conversion layer formed thereon, such layer being formed by heating a preform of Si powder and diamond powder plus a binder, such as, but not limited to, phenolic resin, the purpose of said binder being to hold the Si in contact with the surface of the respective diamond particles, heating said preform to a temperature sufficient to cause the surface conversion reaction to occur, and said metal matrix composite having a thermal conductivity greater than about 300W/m.k.

(75) The composite described in claim 74, having a thermal conductivity greater than about 400W/m.k.

(76) The composite described in claim 74, having a thermal conductivity greater than about 500W/m.k.

(77) The composite described in claim 74, having a thermal conductivity greater than about 600W/m.k.

(78) The composite described in claim 74, wherein metal comprising the matrix is aluminum

(79) The composite described in claim 75, wherein the metal comprising the matrix is aluminum.

(80) The composite described in claim 76, wherein the metal comprising the matrix is aluminum.

(81) The composite described in claim 77, wherein the metal comprising the matrix is aluminum.

(82) The composite described in claim 74, wherein the metal comprising the matrix is magnesium.

(83) The composite described in claim 75, wherein the metal comprising the matrix is magnesium.

(84) The composite described in claim 76, wherein the metal comprising the matrix is magnesium.

(85) The composite described in claim 72, wherein the matrix metal is copper.

(86) The composite described in claim 74, wherein the matrix metal is copper.

(87) The composite described in claim 75, wherein the matrix metal is copper.

(88) The composite described in claim 76, wherein the matrix metal is copper.

(89) The composite described in claim 77 wherein the matrix metal is copper.

(90) The composite described in claim 74, wherein the content of the CVR SiC coated diamond powder in the composite is about 10-60 vol% of the total.

(91) The composite described in claim 74, wherein the content of the CVR SiC coated diamond powder in the composite is greater than about 70 vol% of the total.

(92) The composite described in claim 74, wherein the content of the CVR SiC coated diamond powder in the composite is about greater than about 80 vol% of the total.

(93) The composite described in claim 74, wherein the particle size of the diamond powder used is preferably about 50-150 microns.

(94) The composite described in claim 74, wherein the particle size of the diamond powder used is greater than about 150 microns.

(95) The composite described in claim 74, wherein the particle size of the diamond powder used is greater than about 200 microns.

(96) The composite described in claim 74, wherein the particle size of the diamond powder used is greater than about 300 microns.

(97) A process for making a metal matrix composite with very high thermal conductivity, said composite comprising of metal matrix containing a powder formed of diamond particles dispersed therein, comprising the steps of:

(a) providing the respective diamond particles comprising the diamond powder with a thin layer of SiC by contacting the said diamond particles with a gaseous Si containing species while subjecting said particles to heat at a temperature sufficient to cause the Si of the gas to react with the surface carbon of the diamond particles thereby converting the surface layer of the claimed particles to a thin layer of SiC,

(b) placing the SiC layered particles comprising of the diamond powder in the die cavity squeeze casting apparatus

(c) covering the diamond powder with a sheet of alumina ceramic paper,

(d) introducing by pressure squeeze casting a molten metal selected to form the matrix into the die containing the coated diamond powder, under conditions appropriate to pressure infiltrate the diamond powder with the molten metal, and cooling the die.

(98) The process of claim 97 wherein the metal employed for the metal matrix is aluminum.

(99) The process of claim 97 wherein the metal employed for the metal matrix is magnesium.

100) The process of claim 97 wherein the metal employed for the metal matrix is copper.

101) A process for making a metal matrix composite with very high thermal conductivity, said composite comprising a metal matrix containing a powder formed of diamond particles dispersed therein, comprising the steps of:

(a) providing the respective particles comprising the selected diamond powder with a thin layer of SiC by preparing a mixture of phenolic resin, Si powder and said diamond powder, pressing said mixture to form a preform, and heating said preform to a temperature sufficient to cause a chemical reaction between the Si powder and the carbon surfaces of the respective diamond particles which results in the formation of a thin SiC surface conversion layer on the respective diamond particles,

(b) placing the SiC layered diamond particles in the die cavity of a squeeze casting apparatus,

(c) and covering the diamond powder with a sheet of alumina ceramic paper,

(d) introducing molten metal selected to form the matrix into said die cavity under conditions of heat and pressure effective to pressure squeeze cast the molten metal in the die containing the SiC layered diamond powder, therefor pressure infiltrating the diamond powder with the molten metal, and cooling the die.

(102) The process of claim 101 wherein the metal employed for the metal matrix is aluminum.

(103) The process of claim 101 wherein the metal employed for the metal matrix is magnesium.

(104) The process of claim 101 wherein the metal employed for the metal matrix is copper.

(105) A process for making a metal matrix composite with very high thermal conductivity, said composite comprising a metal matrix containing a powder formed of diamond particles dispersed therein, comprising the steps of:

(a) providing the respective particles comprising the diamond powder with a thin surface layer of SiC by reacting the carbon surfaces of said diamond particles with a gaseous Si containing species at a temperature sufficient to form SiC,

(b) forming a homogeneous mixture of the above SiC layered diamond particles with metal powder selected to form the matrix, and

(c) forming a dense composite by hot pressing the above mixture of SiC surface layered diamond particles and metal powder at a temperature, pressure and cycle time sufficient to fully densify the composite.

(106) A process for making a metal matrix composite with very high thermal conductivity, said composite comprising a metal matrix containing a powder formed of diamond particles dispersed therein, comprising the steps of:

(a) coating the respective particles comprising the diamond powder with a thin layer of SiC by reacting said diamond particles with a gaseous SiC containing species at a temperature sufficient to form SiC,

(b) forming a homogeneous mixture of the above SiC coated powder with metal powder, and

(c) forming a dense composite by hot isostatic pressing the above mixture of SiC coated diamond powder and metal powder at a temperature, pressure and cycle time sufficient to fully densify the composite.

(107) A high thermal conductivity substrate for LDMOS electronic packages, wherein the substrate is a metal matrix composite comprising a metal containing dispersed therein diamond particulates which have a thin SiC coating, said coating having been produced by a chemical vapor reaction process between gaseous SiO and the respective diamond particles.

(108) The substrate of claim 107, wherein the metal employed for the metal matrix is aluminum.

(109) The substrate of claim 107, wherein the metal employed for the metal matrix is magnesium.

(110) The substrate of claim 107, wherein the metal employed for the metal matrix is copper.

(111) The substrate of claim 107, wherein the process utilized to consolidate the metal matrix composite is pressure squeeze casting.

(112) The substrate of claim 107, wherein the metal employed for the metal matrix is aluminum.

(113) The substrate of claim 107, wherein the metal employed for the metal matrix is magnesium.

(114) The substrate of claim 107, wherein the metal employed for the metal matrix is copper.

(115) An electronic package containing an LDMOS chip bonded to a substrate with very high thermal conductivity, wherein said substrate is a metal matrix composite containing particulate diamond, and said particulate diamond has a thin SiC surface coating formed on the respective particles thereof by a chemical vapor reaction process between gaseous SiO and said diamond powder.

(116) The electronic package described in claim 115, wherein the metal employed for the metal matrix is aluminum.

(117) The electronic package described in claim 115, wherein the metal employed for the metal matrix is copper.

(118) The electronic package described in claim 115, wherein the process utilized to consolidate the metal matrix composite is pressure squeeze casting.

(119) The electronic package described in claim 115, wherein the process utilized to consolidate the metal matrix composite is pressure squeeze casting.

(120) The electronic package described in claim 96, wherein the process utilized to consolidate the metal matrix composite is pressure squeeze casting.

(121) A high thermal conductivity substrate for LDMOS electronic packages, wherein the substrate is a metal matrix composite containing diamond particulates which have a thin SiC conversion coating, such coating being formed by heating a preform of Si powder and diamond powder plus a binder, such as, but not limited to, phenolic resin, the purpose of said binder being to hold the Si in contact with the diamond surface, and heating said preform to a temperature sufficient to cause the surface conversion reaction to occur.

(122) The substrate of claim 121, wherein the metal employed for the metal matrix is aluminum.

(123) The substrate of claim 121, wherein the metal employed for the metal matrix is magnesium.

(124) The substrate of claim 121, wherein the metal employed for the metal matrix is copper.

(125) The substrate of claim 121, wherein the process utilized to consolidate the metal matrix composite is pressure squeeze casting.

(126) The substrate of claim 121, wherein the metal employed for the metal matrix is aluminum.

(127) The substrate of claim 121, wherein the metal employed for the metal matrix is magnesium.

(128) The substrate of claim 121, wherein the metal employed for the metal matrix is copper.

(129) An electronic package containing an LDMOS chip bonded to a substrate with very high thermal conductivity, wherein said substrate is a metal matrix composite containing diamond particulates which have a thin SiC conversion coating, said coating being formed by heating a preform of Si powder and diamond powder plus a binder, such as, but not limited to, phenolic resin, the purpose of said binder being to hold the Si in contact with the diamond surface, and heating said preform to a temperature sufficient to cause the surface conversion reaction to occur

(130) The electronic package described in claim 129, wherein the metal employed for the metal matrix is aluminum.

(131) The electronic package described in claim 129, wherein the metal employed for the metal matrix is copper.

(132) The electronic package described in claim 129, wherein the process utilized to consolidate the metal matrix composite is pressure squeeze casting.

(133) The electronic package described in claim 129, wherein the process utilized to consolidate the metal matrix composite is pressure squeeze casting.

(134) The electronic package described in claim 129, wherein the process utilized to consolidate the metal matrix composite is pressure squeeze casting.

(135) An electronic package for high power applications, requiring very high thermal dissipation, comprising a composite structure as defined in claim 1 having a high thermal conductivity further characterized by the presence of a layer of aluminum nitride deposited on the surface thereof, said aluminum nitride providing an electrically insulating layer and also providing a high thermal conductivity path allowing for electronic chips to be bonded to the electrically insulating aluminum nitride layer, and also allowing electronic circuitry to be formed or deposited on the aluminum nitride.

(136) A method of forming a composite structure comprised essentially of a metal matrix having diamond particles dispersed therein, and wherein said diamond particles are characterized by the presence thereon of a surface layer of beta-SiC chemically bonded thereto, comprising the steps of contacting the surface of said diamond particles with a source of SiC under conditions whereby the SiC is deposited on the surface of the diamond particles, causing the deposited SiC to diffuse into the diamond particle on which it is deposited by subjecting to heat at a temperature and for a time adequate to cause such diffusion, thereby forming said surface layer of beta-SiC bonded to said

diamond particles, and forming said composite structure by encapsulating a plurity of said particles in array with said metal in a molten state, whereby the particles of said array bearing the surface layer of beta-SiC are dispersed in a matrix of said metal when the molten metal hardens upon cooling to the solid state.

(137) The method of claim 136 wherein the source of SiC is a SiC organometallic gas.

(138) The method of claim 137 wherein the SiC organometallic gas is selected from among methyltrichloro silane, dimethyldichlorosilane, and triethylsilane.

(139) The method of claim 138 wherein the array of diamond particles are enclosed in a non oxidizing atmosphere prior to being contacted by the SiC organometallic gas and whereas the diamond particles are heated to about 1600 degrees centigrade for about one (1) hour to cause the SiC to diffuse.